The Effect of Rainwater in Concrete Mixture on Concrete Compressive Strength

Adde Currie Siregar[1*], Ulwiyah Wahdah Mufassirin Liana[2], Santi Yatnikasari[3], Fitriyati Agustina[4], Annisa Rahma[5]

[1,2,3,4,5] Departement of Civil Engineering, Muhammadiyah University of East Kalimantan, Indonesia

Article Info

Article history:

Received March 29, 2023
Accepted April 22, 2023
Published April 30, 2023

Keywords:

Rainwater, Compressive Strenght, Concrete

ABSTRACT

Rainwater was acidic water and had a pH generally ranging from pH 5.2 to 6.5. In this research using quantitative research types, where the data was obtained by conducting research in the laboratory. The sample used a cylindrical concrete with a size of 15 x 30 cm with a total of 30 specimens that will be tested for compressive strength with a Machine Compression testing machine to determine the compressive strength of concrete. The results of this study were the compressive strength of concrete using rainwater pH 5.8 and normal PDAM water pH 7.0 as a comparison. The results showed of compressive strength with water pH 7.0 at the age of 3 days 6,638 MPa, 7 days 11,878 MPa, 14 days 17,567 Mpa, 21 days 19,840 MPa and 28 days 21,490 MPa. While the results of compressive strength with rainwater pH 5.8 at the age of 3 days are 9,107 MPa, 7 days 13,830 MPa, 14 days 16,425, 21 days 16,470 and 28 days 17,982 MPa. From the results of the compressive strength above, it can be concluded that the use of rainwater pH 5.8 in concrete mixtures and curing at the age of 28 days had decreased in compressive strength by 16,32% of the compressive strength of PDAM water. Which indicates that PDAM water pH 7.0 was better for mixing concrete and curing compared to rainwater pH 5.8.

Available online at http://dx.doi.org/10.36055/fondasi

Corresponding Author:

Adde Currie Siregar,
Departement of Civil Engineering ,
Muhammadiyah University of East Kalimantan,
Jl. Ir. Juanda No. 15, Samarinda, 75124, Indonesia.
Email: *acs150@umkt.ac.id

1. INTRODUCTION

In civil engineering, concrete is a building material that is often used by many people in the world of construction, both building construction, road and hydraulic engineering. One of the advantages of concrete is strong under pressure and has a very long durability. Concrete is a mixture of hydraulic cement, fine aggregate, coarse aggregate, water and additives [1], [2], [3]. Concrete is a construction material that is mainly used in the construction of roads, buildings, dams, irrigation and ports [4]. In order to get high quality and durable concrete, we must use materials and water according to predetermined conditions so that the planned quality is achieved. In addition, after the concrete is poured, the water in the concrete relatively evaporates and the concrete experiences stress and cracks.

Therefore processing or curing of concrete is necessary. Good concrete treatment is carried out with clean water and according to the rules [5], [6]. According to Simanjuntak et al (2015), the amount of water in liquid concrete is usually more than enough (about 12 liters/bag of cement) to achieve the desired concrete quality to complete the hydration reaction [3], [7].
Water is one of the most important factors in the concrete mixture. Water reacts with cement and forms a binding paste of aggregate [8]. The mixing of concrete and treatment water at least meets the requirements for drinking water, i.e. fresh, odorless, not cloudy when exhaled by air, etc. However, this does not mean that the water used to mix and cure concrete must meet drinking water requirements [9]. Water is one of the main components of the concrete mix and maintenance is important and inexpensive. Water acts as a reactor (± 25% cement) for cement and lubricant between aggregate grains (SNI 03-2847-2002) [10].
Rainwater is acidic water with a pH usually between 5.2 and 6.5 [11]. Meidian et al. in a previous study (2017) entitled "Experimental Study of the Use of Water pH Variations on Normal Concrete Compressive Strength Fc' 25 MPa" with variations in Water pH 4.5 and 6, including Acidic pH and pH 8, 10 and 12, which includes alkaline pH, while neutral or normal water pH is used as a reference [12], [13].
Rahmat Fajri Adha (2019) has been conducted to increase the compressive strength of concrete. 15-30% seawater mixed concrete compared to normal mixed concrete [14]. The sample is cylindrical in shape with 11 cm diameter and 22 cm height. Samples were tested on 7, 14, 28 and 56 days. Using 15% seawater, the concrete has a compressive strength of 17,71 MPa, an increase from normal concrete which is 13,33 MPa. With a mixture of 30% seawater, the compressive strength of concrete is 18,59 MPa. The use of 30% seawater is the largest mixing of seawater in the manufacture of concrete. You must follow the SNI for testing (Indonesian National Standard) [15], [16].
In Syamsul Bahri Ahmad's research (2018) investigated the effect of seawater as mixing water and concrete hardening on compressive strength, porosity and absorption of concrete [17]. Samples with dimensions of 15 cm x 30 cm and 10 cm x 20 cm and cement content of 50 kg/m^3 according to ASTM standards were tested at 28 days old. The results showed that the compressive strength (BLT and BLL) of concrete mixed with sea water increased compared to the compressive strength of fresh water (BTT and BTL), after which the porosity of the concrete decreased. Concrete mixed and treated with sea water (BLL) has a compression of 352,29 kg/cm^2 and a porosity of 17,06% of concrete. The compressive strength (BLT) of concrete mixed with sea water and treated with fresh water was 331,61 kg/cm^2, the porosity of the concrete was 16,87%. The reference concrete for a mixture of fresh water and processed fresh water concrete (BTT) has a compressive strength of 314,05 kg/cm^2 with a porosity of 17,97%. The compressive strength (BTL) of concrete treated with fresh water and sea water is 297,80 kg/cm^2 with a porosity of 16,44%. Good quality concrete is usually considered seawater treated concrete (BTL and BLL).
Pandiangan's research (2014) discovered the quality of concrete can also be affected by the quality of water in the environment [18]. In this study, the calculation steps for SNI 03-2834-1993 were carried out using the ACI (America Concrete Institute) method for planning concrete mixtures [19]. The concrete grade designed in this study uses a superplasticizer, namely Sikament-NN of 1% by weight of cement which is useful for reducing large amounts of water. There are two steps to enter the test object. First, sample processing (hardening) in pure water for 28 days. Second, immersion of the test samples in peat water and control water which was carried out after 28 days of pure water immersion. The first 28 days of immersion was designed so that the samples were first boiled, then the samples were placed in a pot filled with peat water. The test object is cube-shaped, measuring 15 cm x 15 cm x 15 cm, and the test age is 7 days to 28 days. The compressive strength test results in normal water immersion at 7 days were 50.75 MPa and 53.45 MPa at 28 days. The compressive strength test results of peat immersion water at 7 days of age were 54.25 MPa and 53.75 MPa at 28 days.
According to Kurniawandy (2012), his study was to determine the effect of seawater, peat and coconut water on concrete compressive strength, leakage (impermeability of concrete), porosity and absorbency of plain concrete [20]. In this research, the design of the concrete mix follows the calculation method of SNI 03-2834-1993 for fc 22.5 MPa. The benefit of this study is to determine

the effect of seawater, peat and coconut water on the compressive strength of concrete. Cylindrical test specimens with a length of 15 cm and a height of 30 cm used several different types of water for processing, different compressive strength values were obtained. At the age of 28 days, concrete soaked in seawater decreased by 5.89% compared to normal concrete. At the same time, peat water decreased by 20.33% and coconut water by 30.77%. At the age of 90 days the concrete soaked in sea water decreased by 7.62%, peat water by 21.08% and coconut water by 11.60%. At the age of 150 days, concrete soaked in sea water decreased by 15.19%, peat water by 29.86%, coconut water by 29.86%. The seepage value of seawater and peat increased with increasing immersion time, but coconut water did not. Normal water porosity at 28 days old was 3.64%, sea water 5.55%, peat water 58.6% and coconut water 65.6%. The absorption value of 28 days for ordinary water is 1.56%, sea water is 1.74%, peat water is 2.5% and coconut water is 2.79% [20], [21]. Water used for mixing ingredients for making concrete must meet the requirements (SNI 03-2834-2000). Water must be clean and not contain mud, oil and other floating objects that can be seen visually [15], [16].
After carrying out a visual inspection, the water to be used is considered to meet the requirements and can be used in the concrete mixture. because the results show the following properties: water is colorless, odorless, clear (does not contain mud), and there are no other floating objects.
From testing in the laboratory and the results obtained from rainwater testing were 5.8 - 6.0 while the PH of PDAM water was 7.0, Samarinda City Clean Water (PDAM).
Based on the provisions of SNI that the best water to use is clean water that can be consumed or drunk, for this reason, it is necessary to test the clean water of Samarinda City (PDAM) based on Permenkes Number 492/Menkes/Per/IV/2010 (Permenkes No. 492/2010). Th.2010, 2010) as a comparison water [22].

Figure 1. Rainwater PH Testing

Table 1. Samarinda City Clean Water Test Results (PDAM)

No.	Parameter	Unit	Maksimum	Clean Water Test Result
A. Physics				
1	Turbidity	NTU	5	7.15
2	Colour	PtCo	15	29
3	Odor	-	No odor	No odor
4	Taste	-	Tasteless	Tasteless

No.	Parameter	Unit	Maksimum	Clean Water
				Test Result
5	Temperature	°C	Air temperature ±3	30.0
6	pH		6.5 – 8.5	6.88

Source :Burhanuddin (2021) [23]

2. RESEARCH METHODOLOGY

The research method given is experimental which the preparation of cylindrical concrete test specimens measuring 15 x 30 with a rainwater pH of 5.8 – 6.0 and as a comparison PDAM water with a normal pH of 7.0. the goal is how strong the compression test is when comparing the compressive strength between rainwater pH 6.5 and PDAM water which has a pH value of 7.0.
A limited population is used in the research that will be carried out, meaning that this research is carried out by making concrete cylinders measuring 15 cm x 30 cm from the sample, with a total sample of 30 samples for each sample percentage.

Table 2. Number of test objects

Concrete Age	Clean Water PDAM	Rain Water	Number of Test Object
3	3	3	6
7	3	3	6
14	3	3	6
21	3	3	6
28	3	3	6
Number of sampel	**15**	**15**	**30**

3. RESULTS AND DISCUSSION

In this study using rainwater pH 5.8 - 6.0 s as a substitute for water mixing ingredients in normal concrete mixes. Rainwater pH testing was carried out at the UMKT Civil Engineering Laboratory using a litmus paper tester and a pH indicator. It was found that the results of the rainwater pH test were 5.8 – 6.0 while the PDAM water PH was 7.0.

3.1 Mix Design

Mix design calculations obtained from CV. Berkarya Mubarak Bersaudara that used in the USB Development Project for SMA Negeri 4 Samarinda. The mix design can be seen in Table 3, 4 below.

Table 3. Mix Design calculations obtained from CV. Berkarya Mubarak Bersaudara

DAFTAR ISIAN (FORMULIR) RENCANA CAMPURAN BETON

URAIAN	TABEL/GRAFIK PERHITUNGAN	NILAI
1 Kuat tekan karakteristik	ditentukan	K 250 pada 28 hari,bagian cacat 5 %
2 Standar deviasi	diketahui	4,6 Mpa atau tanpa data
		(k = 1,64) sesuai peraturan
3 Nilai tambah margin		(4,6 x 1,64) = 92,7 kg/cm²
4 Kekuatan rerata yang ditargetkan	1 + 3	342,7 kg/cm²
5 Jenis semen	ditetapkan	Semen Merah Putih Tipe I
6 Jenis agregat	ditetapkan	
- Pasir ex.Tenggarong		- SpGr = 2,603
- Pasir ex.Palu		- SpGr = 2,672
- Batu pecah 3/4" (10-20 mm) ex.Palu		- SpGr = 2,682
- Batu pecah 1 1/2" (20-30 mm) ex.Palu		- SpGr = 2,710
- Semen ex.conch		- SpGr = 3,140
7 Faktor air semen bebas	Tabel 2	0,5441
	Grafik 1 atau 2	
8 Faktor air semen maksimum		Tanpa data
9 Slump		± 10 cm
10 Ukuran agregat maksimum		40 mm
11 Kadar air bebas	Tabel 3	(2/3 x 175) + (1/3 x 205) = 185
12 Jumlah semen	(11:8) atau(11:7)	185 : 0,544 = 340 kg/m³
13 Jumlah semen maksimum	ditetapkan	
14 Jumlah semen minimum	ditetapkan	325 kg (pakai bila lebih besar dari 12, lalu hitung 15)
15 Faktor air semen yang disesuaikan		
16 Susunan besar butir agregat halus	Grafik 3 s/d 6	Daerah susunan butir (zone ...)
17 Susunan agregat kasar atau gabungan	Grafik 7 s/d 9	
	Tabel 7	
18 Persen agregat halus	Grafik 13 s/d 15	35,0%
	Perhitungan	
19 Berat jenis relatif agregat gabungan	diketahui	2,68
20 Berat isi beton	Grafik 16	2450 kg/m³
21 Kadar agregat gabungan	(20 - 12) - 11	1925 kg/m³
22 Kadar agregat halus		
- Pasir ex.Tenggarong	21 x 7,35 %	141,49 kg/m³
- Pasir ex.Palu	21 x 27,65 %	532,26 kg/m³
23 Kadar agregat kasar		
- Batu pecah 3/4"(10-20 mm) ex.Palu	21 x 37,05 %	713,21 kg/m³
- Batu pecah 1 1/2"(20-30 mm) ex.Palu	21 x 27,95 %	538,03 kg/m³

Banyaknya bahan (teoritis)	Semen (kg)	Air (kg / l)	agr. Halus (kg)	agr. Kasar (kg)
- tiap m³ dg ketel 5 kg	340	185	673,75	1251,243
- tiap campuran uji 0,05 m³	17	9,25	33,69	62,56

Banyaknya bahan ditimbang	Semen (kg)	Air (kg / l)	agr. Halus (kg)	agr. Kasar (kg)
- tiap m³	340	147,12	Ps. M = 154,13 Ps. P = 558,21 = 712,34	Bt. 1-2 = 712,78 Bt. 2-3 = 537,74 = 1250,52
- tiap 0.05 m³	17,00	7,36	35,62	62,53

Table 4. Table Mix Design

Volume	Water (Kg)	Cement (Kg)	Coarse Aggregate (Kg)	Fine Aggregate (Kg)
3 cylinder	3,385	6,222	23,052	12,412

Based on Table 3,4 the material requirements for 3 cylinders with dimensions of 15 cm x 30 cm are 3,385 kg of water, 6,222 kg of cement, 23,052 kg of coarse aggregate, 12,412 kg of fine aggregate

3.2 Slump Test

The slump test is used to be able to describe the level of ease in the work process. In this study, the design slump was (10 ± 2) cm, using a cement water factor (fas) = 0.58. The results of the slump test can be seen in Table 5.

Table 5. Table Slump Test

No	Concrete Age (day)	Rain Water Slump (cm)	Clean Water Slump (PDAM) (cm)
1	3	10	10
2	7	10	10
3	14	9	10
4	21	10	10
5	28	10	10

reference : Researcher documents (2022)

Based on Table 5, the value of the slump test of rainwater mixed concrete were 10 cm for a 3-day sample, 10 cm for a 7-day sample, 9 cm for a 14-day sample, 10 cm for a 21-day sample and 10 cm for a 28-day sample. Meanwhile for the concrete mixture using clean water (PDAM) were 10 cm for a 3-day sample, 10 cm for a 7-day sample, 10 cm for a 14-day sample, 10 cm for a 21-day sample and 10 cm for a 28-day sample.

Figure 2. Slump Test

3.3 Concrete Curing

Based on SNI 03-2847-2002, Procedures for Planning Concrete Structures for Buildings) maintenance is carried out to prevent concrete temperature or excessive evaporation of water which can have a negative effect on the quality of the concrete produced or on the serviceability of components or structures.

After the test object is removed from the mould, treatment is then carried out on the test object using normal water and Kangen water with a pH of 9.0 during the planned life of the test object, then allowed to stand until the test object is carried out at the compressive strength testing stage.

Figure 3. Concrete Curing

3.4 Compressive Strength

The purpose of concrete compression testing is to obtain a compressive strength value using the correct method. The definition of compressive strength of concrete is the amount of load per unit area that causes a concrete block to collapse when loaded with a certain load from the force pressure generated by a press machine.

Figure 4. Concrete Compressive Strength Test Machine

3.4 Mix Design Calculation

The compressive strength of concrete mixed with rain water at 28 days had a lower compressive strength than the clean water (PDAM) mixture at 28 days, respectively 17,982 MPa and 21,490 MPa.

Table 6. Concrete Compressive Strength Aged 28 Days

Age (Day)	Rain water pH 5.8	Clean water (PDAM) pH 7.0
3	9.107	6.638
7	13.83	11.878

	14	16.425	17.567
	21	16.47	19.840
	28	17.982	21.480
5	28	10	10

From Table 6, the percentage decrease in the compressive strength of rain water on clean water (PDAM) can be obtained from the following calculations:
compressive strength:
3 days = (6.638-9.107)/6.638 x 100 % = - 37.19 %
The minus value indicated an increase of 37.19% compared to the compressive strength of clean water (PDAM).
7 days = (11.878-13.830)/11.878 x 100 % = - 16.44 %
There was an increase of 16.44% compared to the compressive strength of clean water (PDAM).
14 days = (17.567-16.425)/17.567 x 100 % = 6.50 %
A positive value indicated a decrease of 6.50% compared to the compressive strength of clean water (PDAM).
21 days =(19,840-16,470)/19,840 x 100 % = 16.98 %
There was a decrease of 16.98% compared to the compressive strength of clean water (PDAM).
28 days =(21.490-17.982)/21.490 x 100 % = 16.32 %
There was a decrease of 16.32% compared to the compressive strength of clean water (PDAM).
Comparison of the compressive strength of concrete aged 28 days can be seen in Figure 5.

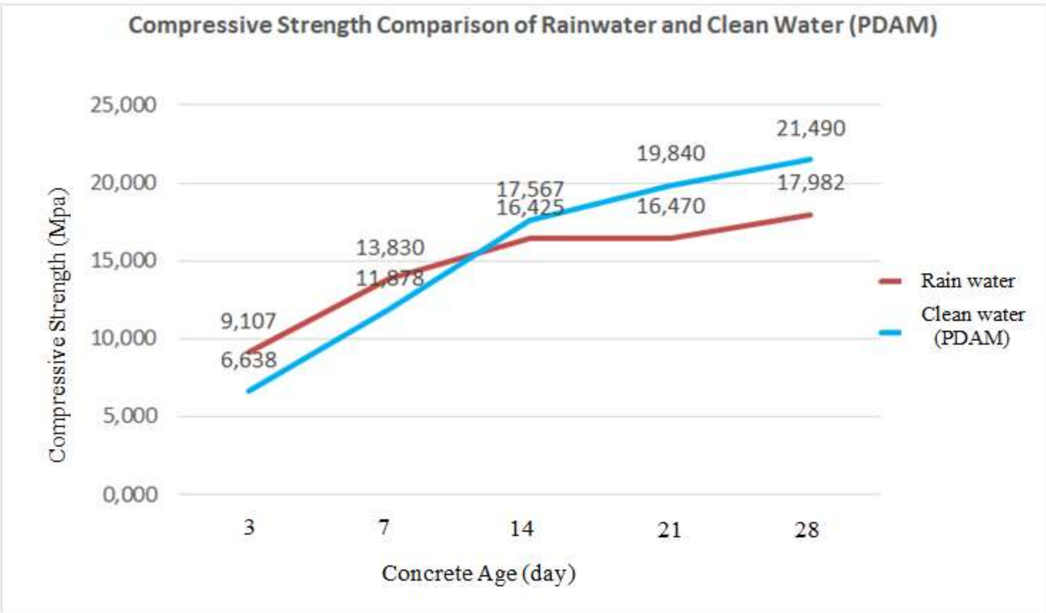

Figure 5. Compressive Strength Comparison of Rainwater and Clean Water (PDAM)

In Figure 5, it can be seen that the graph of the compressive strength comparison of concrete mixed with rainwater at the age of 3 days and 7 days is higher than the compressive strength of clean water mixture (PDAM). Meanwhile it decreased compared to the clean water mixture (PDAM) at the age of 14, 21 and 28 days.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

Based on the results of this study, the authors draw the following conclusions:

1. The compressive strength of rainwater mixed concrete has a higher compressive strength at 3 days and 7 days than the clean water mixture (PDAM) while at 14 days, 21 days and 28 days it experiences a decrease in compressive strength. The compressive strength of using rainwater and clean water (PDAM) cannot meet the design compressive strength of 25 MPa.
2. The use of rainwater in normal concrete mixtures produces high compressive strength at the initial age and decreases at the age of 28 days. This is influenced by the pH level of rainwater which is acidic with a pH value of 5.6. While the use of PDAM water in normal concrete mix, the compressive strength has increased from 3 days to 28 days but does not reach the design compressive strength.

4.2 Suggestions

Suggestions are drawn from the test results, so that the following recommendations can be made with these suggestions:

1. The chemical content of rainwater needs to be further investigated to increase its effectiveness.
2. Preparation of test sample requires accuracy in mixing, compacting, maintaining and reading the concrete compressive strength indicator.

BIBLIOGRAPHY

[1] Mulyono, Tri. 2003. Teknologi Beton. Yogyakarta: Penerbit Andi.
[2] Mulyono, T., 2004. Teknologi Beton, Edisi Kedua, Andi, Yogyakarta.
[3] Tjokrodimuljo, K., (2007), Teknologi Bahan Konstruksi, Buku Ajar, Jurusan Teknik Sipil dan Lingkungan Fakultas Teknik, Universitas Gadjah Madah Yogyakarta.
[4] A. Allahverdi and F. Škvára, “Acidiccorrosion of hydrated cement basedmaterials. Part 1. Mechanism of thephenomenon,” Ceram. - Silikaty, vol. 44,no. 3, pp. 114–120, 2000.
[5] H. Canakci, M. Hamed, F. Celik, W. Sidik, and F. Eviz, “Friction characteristics of organic soil with construction materials,” Soils Found., vol. 56, no. 6, pp. 965–972, 2016.
[6] Yatnikasari, Santi., Fitriyati Agustina, Vebrian, Sahlan Sunaryo, Muhammad Iqbal. (2023). Pemanfaatan Abu Limbah Kulit Galam sebagai Pengganti Semen dalam Campuran Beton. *Konferensi Nasional Teknik Sipil (KonTekS) Ke - 16*, Vol : 16, Hal : 421–426.
[7] Surdia, T. (2005). Saito. S.(992). Pengetahuan Bahan Teknik, Pradnya Paramita. Jakarta.
[8] H. J. Zhuang, H. Y. Zhang, and H. Xu,“Resistance of geopolymer mortar to acidand chloride attacks,” Procedia Eng., vol.210, pp. 126–131, 2017.
[9] Effendi,Hefni. 2003. Telaah Kualitas Air. Kanisius. Yogyakarta.
[10] SNI 03-2847-2002, Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung, Badan Standar Nasional.
[11] Budiwati, T., Budiyono, A., Setyawati, W., & Indrawati, A. (2010). Analisis korelasi pearson untuk unsur-unsur kimia air hujan di Bandung. Jurnal Sains Dirgantara, 7(2).
[12] S. Meidiani, A. Rajela, M. F. . Hartawan,and A. Fartawijaya, “Studi EksperimenPenggunaan Variasi pH Air Pada KuatTekan Beton Normal f’c 25 MPa,” inSeminar Nasional Strategi PengembanganInfrastruktur ke-3 (SPI-3), 2017, pp. 88–94.
[13] A. Nugroho et al., “Pengaruh Penambahan Larutan Asam Terhadap Setting Time danKuat Tekan Geopolimer Berbahan DasarFly Ash Tipe C,” J. Dimens. Pratama Tek.Sipil, vol. 6, no. 1, pp. 1–8, 2016.
[14] Rahmat Fajri Adha (2019). Pengaruh Penggunaan Air Laut Terhadap Kuat Tekan Beton. Tugas Akhir. Padang. Universitas Andalas.
[15] SNI 03-1974-1990, Metode Pengujian Kuat Tekan Beton, Badan Standar Nasional.
[16] SNI 03-2834-2000, Tata Cara Pembuatan Rencana Campuran BetonNormal, Badan Standar Nasional.
[17] Syamsul Bahri Ahmad (2018). Investigasi Pengaruh Air Laut Sebagai Air Pencampuran Dan

Perawatan Terhadap Sifat Beton. Journal INTEK. Vol 05 (1) : 48-52.
[18] Pandiangan, Jaya Alexander. 2014. Ketahanan Beton Mutu Tinggi Dilingkungan
[19] Aci 201, “201.2R-08 Guide to DurableConcrete,” Concrete, pp. 0–54, 2008.
[20] Kurniawandy, A., Darmayanti, L., & Pulungan, U. H. (2012). Pengaruh Intrusi Air Laut, Air Gambut, Air Kelapa, Dan Air Biasa Terhadap Kuat Tekan Beton Normal. Jurnal Sains dan Teknologi, 11(2).
[21] W. Adi Putra, M. Olivia, and E. Saputra,“Ketahanan Beton Semen PortlandComposite Cement (PCC) di LingkunganGambut Kabupaten Bengkalis,” J. Tek., vol.14, no. 1, pp. 27–34, 2020.
[22] Permenkes Nomor 492/Menkes/Per/IV/2010 (Permenkes No. 492/Th.2010, 2010)
[23] Burhanuddin, B., & Zulkarnain, I. (2021). Analisa Kandungan Air Sungai Mahakam Kota Samarinda Sebagai Air Pencampur Beton. Borneo Student Research (BSR), 3(1), 1072-1083.